



## Specification

## Title of the Invention

Root Zone Injection Surface Irrigation System

## Background of the Invention

1. Field of the Invention

This invention relates to subsurface irrigation systems, but remarkably is a surface irrigation apparatus and method; this surface irrigation apparatus includes a plurality of unique water injection nozzles to uniformly deliver water and nutrients downward into the subsurface root zone area while also inhibiting root infiltration into the water distribution apparatus.

2. The Prior Art

Subsurface watering systems are known in the art and incorporate various devices for distributing the water. By definition, subsurface watering systems are located in arrangements beneath the soil surface. A primary reason for using a subsurface *watering system* is that it provides substantial savings in the quantity of water used. Conventional sprinkling systems for lawn and landscape irrigation are usually permanently installed and involve a network of underground pipes to supply the irrigation water to above-ground sprinkler heads spaced throughout the area to be watered. A series of valves regulate selected portions of the irrigation network and can be either manually controlled or operated by automatic timers. Although such permanent sprinkler systems are quite commonplace, there are many problems associated with these types of sprinkler systems.

Water consumption is perhaps the most serious problem since a very high percentage of the sprinkled water is lost to evaporation, particularly during hot, windy weather conditions. Further, many sprinkler systems deliver the water at a rate that exceeds the ability of the soil to absorb the water with the result that there is excessive runoff and/or the creation of swampy areas. Both of these

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conditions waste valuable water resources. Additionally, sprinkler systems are always designed so that the spray from each sprinkler head overlaps the spray from adjacent sprinkler heads. This overlap further exacerbates water waste and runoff problems.

Another problem with conventional sprinkler systems results from overspray striking automobiles, buildings, windows, and the like, particularly on windy days. This problem is particularly acute in arid regions of the country since the water in these regions generally contains relatively high concentrations of dissolved salts. The result is that these salts are deposited on the adjacent surfaces where it creates an unsightly deposit when the water evaporates. It is a common sight in these regions to see bricks, windows, automobiles, and the like stained by these unsightly deposits.

Above-ground sprinkler systems also restrict usage of the lawn area watered both during watering and for a period of time thereafter until the grass has become sufficiently dry. Accordingly, it is customary to water golf courses, parks, and public areas, for example, at night so that the grass will be sufficiently dry for use the next day. However, this practice exacerbates another problem in that it makes the grass more susceptible to attack by fungi such as mold, moss, etc. In agriculture this same practice makes crops more susceptible to mold, mildew, rust, aphids, whitefly, slugs, snails and other pest infestation – not to mention the promulgation of weeds.

Another problem with above-ground sprinkler systems is that the sprinklers themselves are easily damaged by lawn care equipment, golf carts, tractors, etc. Some sprinklers are intentionally damaged by acts of vandalism, causing a tremendous waste of water until the damaged sprinkler is located and repaired. A further problem is that injuries sometimes occur by inadvertent contact with sprinklers during use of an area or merely by accidentally tripping over them.

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Elaborate drip irrigation systems are also known in the art, but they too have their limitations. Emitters are easily clogged and the delicate, flexible tubing is subject to damage during cultivation, weeding, harvesting, etc. In addition, these systems must be continually pressurized for long periods of time in order to deliver sufficient quantities of water or nutrients into the soil. Drip irrigation devices are most advantageous where the soil is compacted, or has very slow absorption. However, in most irrigation applications the topsoil has been amended and tilled to promote plant root growth; thus, there is little need for drip irrigation merely to facilitate soil absorption. Much water is lost to evaporation in drip irrigation systems as well.

In the area of water conservation, it has not been practical or economically feasible to use grey water in above-ground sprinkling systems. This arises from the impracticality of using grey water due to health and sanitation issues, odors, etc. Various underground irrigation systems are known in the art. As the name implies, these systems are designed to deliver the water to distribution outlets spaced at intervals along underground tubing. One patent, for example, (U.S. Pat. No. 3,479,825; Hellstrom) discloses a subsurface irrigation system wherein an artificial barrier is buried a substantial distance below the surface of the soil in order to create an artificial water table below the roots of the crops growing in the soil. Water is introduced into the soil through buried pipes or through deep ditches in order to cause the water to migrate laterally throughout the soil. The barrier prevents the water from disappearing into the earth.

Reese (U.S. Pat. No. 4,060,991) discloses a subsurface irrigation system for plants specifically designed to eliminate problem of roots fouling the water distribution system. An underground, vented chamber includes a float valve mechanism to regulate the quantity of water in the chamber. A pipe carries water from the chamber to a moisture pit. Both the pipe and the moisture pit are filled with sand to provide a capillary path for the water while serving as a root barrier.

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Brandt (U.S. Pat. No. 4,065,926) discloses a subterranean irrigation system wherein a coarse screen or grid of flexible material having internal interconnecting passages for the flow of water. The grid is buried underneath the area to be watered. Orifices are distributed along the interconnecting passages to release the water by gravity feed from a source or reservoir.

Funkhouser, Jr. (U.S. Pat. No. 4,832,526) discloses an underground watering system wherein a plurality of equally spaced, shallow water reservoir trenches is prepared. The trenches are formed with rounded surfaces and are lined with a waterproof liner. A water distribution pipe is laid in each trench and the trenches are filled with a fine stone aggregate. A water permeable fabric is placed across the entire area to be watered. A relatively course layer of aggregate is placed over the water permeable fabric followed by an upper layer of relatively fine aggregate. A sod layer is then placed on top of the fine aggregate where its roots receive moisture drawn up through the various layers by capillary action.

U.S. Pat. No. 5,374,138 delineates a lawn area subsurface irrigation system wherein special conduits spaced at predetermined intervals deliver the water into the soil at the root level. A deflector system is included as part of the conduit to block the downward movement of water in the deflecting area below the conduit.

Each of these prior art references is directed to solving problems associated with above-ground sprinkling systems and subsurface irrigation systems. However, unless the subsurface irrigation system is provided with very elaborate and, therefore, costly shielding systems such as those taught by Reese (U.S. Pat. No. 4,060,991) or Funkhouser, Jr. (U.S. Pat. No. 4,832,526), the orifices by which the water is released into the soil will be highly susceptible to encroachment by roots from the plant. The fact that roots will seek out a source of water and, indeed, grow into the source of water to such an extent as to eventually plug the water conduit is a well known fact. For example, an entire service industry has been developed to address this phenomenon in the area of rotary de-rooting of sewer

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lines. Subsurface lawn irrigation systems will clearly encounter the same phenomena although on a smaller scale but with the same consequences, namely, plugged orifices.

It would, therefore, be a significant advancement in the art to provide a surface irrigation system that delivers water or nutrients downward into the subsurface plant root zone without the disadvantages of above-ground sprinkler systems or drip irrigation systems, nor the expense of elaborate subsurface irrigation systems.

It would also be a significant advancement in the art to inject exact amounts of water or nutrients directly into the root zone using a surface irrigation method.

A further advancement of the art would be to employ self-cleaning injection nozzles producing a jet stream of water capable of drilling cylindrical holes into the soil, thereby increasing the absorption of water or nutrients into the plant/crop root zone area. This advancement of the art delivers a precise amount of water or nutrients directly downward into the root zone for optimum plant cultivation while eliminating undesirable runoff that often contaminates our lakes and streams.

It would be a significant advancement of the art to employ a surface irrigation system that is visible, yet supplies water or nutrients directly down into the soil root zone. Accidental damage to such a system is minimized, since it hugs the ground surface and can be seen and avoided, unlike a conventional subsurface watering system which cannot be seen and drip irrigation systems that are easily damaged. Such visibility facilitates easy inspection and access to the apparatus when an adjustment is necessary; it also allows for simple weeding, cultivation and maintenance, unlike drip irrigation tubing and other traditional watering systems. Conduits can be manufactured or painted to match the ground surface or be lightly covered with surface litter (straw, leaves, manure, sawdust, peat moss, sand, etc.) to visually “hide” the conduits, if desired, for cosmetic reasons.

A further advancement of the art would be to employ a surface irrigation system that could quickly and easily replace existing in-ground sprinkler systems making them safer, cheaper, and much more efficient, while saving enormous amounts of water.

Such a novel apparatus and method is disclosed and claimed herein.

### Brief summary and objects of the Invention

This invention is a unique surface irrigation apparatus and method wherein a plurality of water distribution conduits is arranged in a predetermined spacing and/or grid arrangement to irrigate a specified area. Each delivery conduit includes a plurality of injection nozzles placed at spaced locations along its length, each nozzle directing a jet stream of water or nutrients directly downward into the soil root zone. The number and spacing of the injection nozzles, the diameters of the distribution and delivery conduits, the size of each injection nozzle, and the number and types of control valves or automatic timers are all dependant upon the pressure of the water or nutrient supply source, the total surface area being irrigated, and the amount of water necessary for the particular application, such as a home vegetable garden, a crop of corn or soybeans, a vineyard, a freeway median, city landscape, etc. In this regard, the apparatus and method is extremely versatile toward a variety of irrigation applications. Due to the design and use of injection nozzles, filters for this apparatus are normally not needed due to the fact that the system is pressurized and the nozzles are of sufficient diameter to be self-cleaning. It would require a fairly large particle to clog an injection nozzle.

It is, therefore, a primary object of this invention to provide improvements in surface irrigation apparatus affording delivery directly into the root zone where it

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is needed.

It is another object of this invention to provide improvements in the method of delivering water and nutrients to root zones of plants, trees, and shrubs.

Another object of this invention is to provide a surface irrigation apparatus wherein the distribution and delivery conduits are arranged in any manner to deliver water or nutrients directly into the root zone of plants, trees, and shrubs at any specified location.

Another object of this invention is to provide a surface irrigation apparatus wherein the distribution and delivery conduits are arranged in a modular spaced grid array for ease of fabrication, handling, and installation.

Another object of this invention is to provide a plurality of spaced injection nozzles in each delivery conduit.

Another object of this invention is to provide an injection nozzle at any specified location along the delivery conduit.

Another object of this invention is to produce a water injected cylindrical hole water-drilled into the soil to aid in the rapid absorption and diffusion of the water or nutrients into the root zone of plants.

Another object of this invention is to provide control valves or automatic timers for automatically controlling the delivery of water or nutrients to the root zone irrigation apparatus.

Another object of this invention is to provide optimum amounts of water or nutrients being delivered by the apparatus and method by controlling: the diameter of all supply and delivery conduits; the diameter of each injection

nozzle; the number of injection nozzles; the pressure of the water or nutrient supply; and the duration and frequency of operation.

These and other objects and features of the present invention will become more readily apparent from the following description in which preferred and other embodiments of the invention have been set forth in conjunction with the accompanying drawings and claims.

#### Brief description of the several views of the drawings

FIG. 1 is a plan view of the novel root zone injection surface irrigation apparatus of this invention. It depicts a typical grid arrangement of the apparatus and method, showing the supply conduits [1, 5], the delivery conduits [2], and the location and spacing of the plurality of injection nozzles [4] along each delivery conduit [2]; however, each injection nozzle [4] is directed downward into the soil.

FIG. 2 is also a plan view of the novel root zone injection irrigation apparatus of this invention. It depicts a typical grid arrangement of the apparatus and method, showing the supply conduits [1, 5], the delivery conduits [2], and the location and spacing of the plurality of injection nozzles [4] along each delivery conduit [2], also with each injection nozzle [4] directed downward into the soil. However, this drawing illustrates the fact that the grid arrangement is entirely modular; it also shows that the supply conduits can supply the delivery conduits in a plurality of ways.

FIG. 3 is a plan view of a section of the novel root zone injection surface irrigation apparatus where the supply conduit is located at the top of a bank or slope, while also functioning as a delivery conduit with a plurality of injection nozzles spaced at regular intervals along its length. At specified locations, additional delivery conduits are arranged so as to irrigate and nourish any plants, trees, or shrubs that are located in any specific area.

FIG. 4 depicts a section of a typical arrangement of the apparatus and method around the root zone of a single large plant or tree. In such an arrangement, water or nutrients can be disseminated to irrigate the entire root zone area of even the most mature trees. There are many instances in southern California, Arizona, and other arid regions of the country where large, mature trees are transplanted to new construction sites, shopping malls, and commercial and residential developments, necessitating such a specialized irrigation and feeding method for their successful cultivation. Ideally, the delivery conduit should be circular; however, there is currently no inexpensive source of circular conduit suitable for such a purpose.

FIG. 5 is a fragmentary, exploded perspective view of the novel injection nozzle for the root zone injection surface irrigation apparatus. It depicts a typical 1/16 inch cylindrical hole located along the base of each delivery conduit, typically at 12 inch intervals running its entire length.

FIG. 6 is also a fragmentary, exploded perspective view of a section of a delivery conduit, depicting two of a plurality of novel injection nozzles for the surface root zone injection irrigation apparatus. Again it illustrates the typical 1/16 inch cylindrical hole shown in two adjoining injection nozzles located along the base of each delivery conduit. The injection nozzles are typically spaced at 12 inch intervals along the entire length of each delivery conduit.

## Detailed Description of the Invention

Root Zone Injection Surface Irrigation System is a surface irrigation apparatus and method that includes: 1) a pressurized source of water or nutrients; 2) a plurality of either manual valves or automatic timers to regulate the amount of water or nutrients being applied and the frequency of application of said water or nutrients; 3) a plurality of water or nutrient supply conduits and water or nutrient delivery conduits; 4) a plurality of unique injection nozzles located at specified intervals, or locations, along each delivery conduit for injecting water or nutrients directly downward into the subsurface root zone of plants, trees, and shrubs.

Referring now to FIG. 1, the novel surface irrigation apparatus and method of this invention is shown in a typical surface grid layout pattern having supply conduits [1, 5] (shown in 2 places) and distribution conduits [2] (shown in 5 places). Since in this configuration all conduits are interconnected, distribution conduits also act as supply conduits. The injection nozzles are indicated by solid dots [4] along the bottom surface of the distribution conduits, injecting water or nutrients directly downward into the soil.

A series of manual or automatic control valves (not shown) regulate the supply of water or nutrients to each arrangement of delivery conduits. There is a control valve to regulate the supply of water or nutrients to each grid (or other) arrangement of delivery conduits. This regulated supply of water or nutrients can be obtained from a conventional water source or a plurality of water supply sources including secondary water such as irrigation water, grey water, or the like. A plurality of diameters of the supply and delivery conduits may be necessary to maintain a minimum system pressure to regulate the amount of water delivered by each injection nozzle throughout each grid segment; once established, one can regulate the frequency and duration of irrigation necessary for the specific application. The amount of disseminated water or nutrients can be easily adjusted to the specific plants, trees, or shrubs being cultivated, the specific climate, and the soil conditions of the region. One can determine such data in gallons per minute throughout the grid area or in liters (or milliliters) per minute at each injection nozzle

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location. (A typical delivery rate at each injection nozzle is approximately  $\frac{1}{2}$  liter per minute).

Referring now to FIG. 5, the novel surface irrigation apparatus and method utilizes a unique injection nozzle, as shown in detail in this exploded, perspective view. This injection nozzle embodies a 1/16 inch diameter cylindrical orifice (typical) at specific intervals throughout each delivery conduit. This cylindrical orifice can be larger or smaller, depending upon the delivery rate desired for the particular application. However, the 1/16 inch diameter cylindrical orifice appears to be optimum because it is both large enough to prevent clogging and small enough not to over-irrigate the root zone area. There is a design interrelationship between: the number and diameter of injection nozzles in each grid system; the pressure of the system; and the diameters of both the supply and delivery conduits. All these embodiments are interdependent design parameters. A typical section of a grid arrangement is shown in FIG. 2.

In this novel surface irrigation apparatus and method the injection nozzles are located in each delivery conduit in pre-selected patterns and of any predetermined size. A typical spacing is shown in FIG. 6. The particular pattern chosen is a function of various factors associated with the application of the surface irrigation apparatus and the plants being cultivated. For example, in those applications on a steep bank or a sloped surface, it may be preferable to orient each injection nozzle at the drip line of each plant, tree, or shrub [as shown in FIG. 4] in lieu of using regular spaced intervals as one would use for a crop of corn or soybeans. In some applications on steep slopes, this novel surface irrigation apparatus and method can be located as a single delivery conduit along the top of the slope. As it irrigates the soil root zone, the water or nutrients can diffuse into the entire slope area preventing wasteful runoff caused by surface sprinkler systems. This unique apparatus can easily be adapted to irrigate any location merely by running a delivery conduit to that location and providing injection nozzles at optimum locations along the drip line into the root zone [FIG. 3]. In this application, the delivery conduit would also be the supply conduit, having distribution injection nozzles only where needed along the conduit.

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As an added feature to surface irrigation apparatus, valves can be configured as a remotely operated valve electrically coupled to a controller through a control line. One can use a conventional controller having the necessary programmable features such as times of operation of valve as well as duration for the delivery of water into the supply conduits. A controller can also be automated by the inclusion of a moisture sensor electrically coupled to the controller by a moisture sensor line. Electrical power is supplied to the controller by either a power line, use of solar cell arrays, or other available power source. In this manner surface irrigation apparatus can be selectively controlled to deliver precise, predetermined quantities of water to plants, trees, and shrubs at any time and under any pre-selected conditions. Over the past ten years, or so, I have found it most beneficial to provide water or nutrients once per day for approximately three to five minutes per grid, manually adjusting the duration and/or frequency of irrigation as the season or weather dictates. For a home vegetable garden this apparatus and method of surface irrigation saves enormous amounts of water or nutrients over conventional hand watering, sprinkler systems, and the like. Each plant receives only the amount of water or nutrients that it needs for optimum growth – no more, no less!

### The Method

Root zone injection irrigation apparatus is a surface irrigation system that may require that the irrigation area be tilled, plowed, spaded, or otherwise prepared for conventional cultivation.

The novel method of this invention utilizes standard irrigation water supply valves and supply conduits used in above-ground sprinkler systems, thus affording an independently controlled water supply to each zone being irrigated. Along the surface of the ground distribution conduits are then affixed in a parallel relationship properly spaced along the surface of the soil to be irrigated and coupled to the supply conduit(s) in fluid communication therewith. Injection nozzles are located along the base of each

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distribution conduit at pre-selected intervals directing water or nutrients downward into the soil root zone along the entire row of plants.

Root Zone Injection surface irrigation apparatus is now installed along the surface of the soil to be irrigated and is ready for operation. The soil root zone is easily and uniformly irrigated by simply opening the valve to distribute water to each network of distribution conduits each having a plurality of injection nozzles at pre-selected intervals along its entire length. Each distribution conduit services a single row of plants. Thus a plurality of distribution conduits services a plurality of rows of plants. The total number of distribution conduits in a single grid arrangement supplied by a single valve is dependent upon: the total number of gallons per minute available from the source of supply; the diameter and length of the supply conduits; the diameter and length of the delivery conduits; the size and number of injection nozzles, and the design pressure of the entire system.

It is desirable to maintain a system pressure of 40 to 60 pounds per square inch (psi) throughout the grid arrangement so that a uniform quantity of water is injected downward into the soil root zone by each injection nozzle. An interconnected grid of supply and delivery conduits facilitates this uniform irrigation embodiment. Once an optimum layout has been established for one control valve, one merely repeats the process in a modular fashion for the next valve, and the next, until the entire area is covered by this novel surface apparatus and method. Each valve is then set to operate in a timed sequence depending upon the irrigation needs for the particular crop being cultivated. This system provides a great deal of versatility to deliver very precise quantities of water or nutrients to each plant root zone. It is often desirable to place one injection nozzle for each plant along the row. Corn, soybeans, tomatoes, zucchini, okra, etc. are all good candidates for such a design. Thus the optimum crop spacing between plants and between rows dictates the grid layout: the row separation determines the spacing between distribution conduits; and the plant separation determines the spacing between injection nozzles.

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Since water is distributed directly into the root zone, there is minimal loss of water through evaporation and maximum penetration into the soil due to the injection, or water-jet, action of the injection nozzles. Further, water can be delivered to the root zone even during hot, windy weather or other conditions when sprinkler irrigation is either prohibited or discouraged. Water can be delivered to plants, trees, and shrubs at any time of day and under any types of conditions. This is made possible because the root zone injection irrigation apparatus is specifically configured to deliver only the precise amount of water or nutrients necessary for said plants, trees, and shrubs so as to eliminate over-watering, runoff, puddles, swampy areas, runoff, weed growth, and the like. Further, the inclusion of a moisture sensor and controller allows the operator (not shown) to selectively adjust the operation of surface irrigation apparatus to precisely control the delivery of water to said root zone. For example, if the irrigation area has been recently seeded, the controller can be programmed to deliver water at such a rate as to keep the upper surface of the soil zone constantly moist for proper seed germination. After germination, the controller can be reprogrammed to provide only the most favorable amount of water or nutrients to the root zone area for optimum plant growth. Delivery of water or nutrients directly downward into the plant root zone helps eliminate the problem of weed germination, but more importantly delivers the precise amount of water or nutrients necessary for optimum plant growth directly to the plant, rather than over the entire vicinity surrounding the plant. Thus, with this unique apparatus each plant receives only the water or nutrients it needs to flourish, rather than wasting vast amounts of water or nutrients irrigating and fertilizing an entire area.

The use of root zone injection surface irrigation apparatus for watering such areas as agricultural crops, city parks and landscapes, roadway medians and the like, means that watering need not be done at night, since night watering is notorious for its exacerbation of fungi, mold, mildew problems as well as the promotion of moisture-loving insects, etc. Further, the application of fertilizers, systemic insecticides, selective herbicides, and the like, can be delivered directly into the soil root zone in exact amounts with little or no runoff, thereby minimizing environmental contamination or any exposure risk to humans or wildlife.

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The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.